Size Estimation of Injecting Drug Users through the Network Scale-Up Method in Thailand

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Background and objective: *Hard to reach populations such as injecting drug users (IDU) is one, among the most at risk, for HIV infection in Thailand. This study examined an indirect method for estimating the size of IDU population in Thailand.*
Material and Method: *A household survey was conducted among 3,790 individuals who were 12-65 years old, stayed at least 3 months in the sample households. Through, reference groups and summation procedure, personal network size was estimated. The participants were asked to identify the number of their acquaintances whom they perceived to be IDU. Using the survey results with the network scale-up method, the IDU population size was estimated.*
Results: *The personal network size was estimated to be 71,000 IDUs. The estimated prevalence of total population in Thailand was 110 IDUs in 100,000 population.*
Conclusion: *Estimating population sizes through the network scale-up method appeared to be an effective method in terms of time, simplicity, and low cost as compared with more-conventional methods.*

Keywords: *Injecting drug users (IDU), Network scale-up method (NSU), Size estimation, Thailand*

HIV/AIDS is a major global health challenge, with 35.3 million people estimated to be living with HIV as of the end of 2012, according to the Joint United Nations Program on HIV/AIDS (UNAIDS)[1]. In Thailand, the estimated number of people living with HIV is 451,258 in a country with a total population of 64.5 million as of 2013[2]. This figure translates to a low-level epidemic. Although, the number of people newly infected with HIV in 2013 was 8,134 and has been decreasing, it is still under national target. The data from the projections for 2012 and 2013 show 90% of new adult HIV infections were transmitted from unprotected sex. Although injecting drug users (IDU) was not highlighted for new infection due to lack of data, it was reviewed and identified for future priority actions.

When designing effective policy interventions for public health issues, it is crucial to identify the size of the high-risk populations and the epidemiological trends within those populations. In particular, HIV responses at a national level can be strengthened by better information on the number of people in a given population who engage in behaviors that increase their risk for HIV. By estimating the size of the populations at higher risk for HIV, a country can revise its strategic plans, allocate resources appropriately, improve the modeling of its epidemic, and advocate services for those populations[3]. Unfortunately, the populations most at risk for HIV infection, such as IDUs are often hard to reach and thus present significant size-estimation challenges. The global data on IDU population size, for example, is insufficient, especially in the low- and middle-income countries[4]. For these reasons, UNAIDS, WHO and their partners have explored various methods for estimating the size of key hard-to-reach populations that are at high risk for HIV[5]. In the case of Thailand, estimating the population size of IDU is crucial in the AIDS response considering the important contribution that HIV risk behaviors associated with HIV transmission in the country. In 1994, Mastro et al used a capture-recapture method in Bangkok to obtain an estimate of 36,000 IDUs[6]. Based on respondent-driven surveys (RDS) in Bangkok, national estimated using best weighing methods available in each period come up with 160,000 IDUs during 1980-1995 to 38,380 IDUs in 2008[7,8]. The national household survey had previously been conducted in Thailand in 2010. Network Scale Up (NSU) method was employed to estimate hard to reach populations. The survey estimated 40,300-97,300 IDUs[9]. However, data on the population size of these groups are controversial

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due to the wide range of the estimation resulting from barrier effect as well as transmission error[9,10].

Although determining the true prevalence of IDU and thus the potential true size of the IDU population is desirable, the high cost and difficulty of approaching hidden populations have prevented policy makers and the research community from thoroughly and frequently conducting such methods in Thailand. In light of the importance of obtaining a reliable and up-to-date estimate of the size of the IDU population, which are most-at-risk of acquiring HIV infection in Thailand, this study examined the use of an innovative and simple method for estimating the size of the IDU population. It is the second Thai study at national level to utilize the network scale-up method, which is increasingly used in public health to estimate the size of hard-to-reach populations. This study modified the method used in 2010 to minimize a barrier effect as well as transmission errors during the survey, resulting in better estimates.

Material and Method
The network scale-up method
The network scale-up method is a social network method for estimating the size of hard-to-reach populations. There are three steps in the network scale-up method[11]. The first step assumes the relationship among personal network size, total population, and size of target sub-population. The second step is to calculate personal network size. The third step is to estimate the group of interest. This method is applied to the epidemiological surveys of hard-to-reach populations when more direct methods are difficult to apply.

The survey
The survey was conducted among 3,790 respondents in 2014. According to registered population from the Department of Provincial Administration, Thai population at the time of 2013 was 64,785,909 people[12]. Stratified four stages sampling was used. Thailand was stratified into five geographical zones; the northern region with 11,825,595 people in 17 provinces, the northeastern region with 21,775,407 people in 20 provinces, the central region with 16,366,870 people in 25 provinces, the southern region with 9,131,425 people in 14 provinces, and Bangkok metropolitan area with 5,686,252 people in 50 districts. Nine provinces and three districts were selected through simple random sampling: two provinces from the north, two provinces from the northeast, three provinces from the central,

two provinces from the south, and three districts from Bangkok metropolitan area. Enumeration districts in the selected area were ordering based on size of the population. According to size of population in each stratum, 68 enumeration districts were systematically sampling with probability proportional to size. In each enumeration district, household settlements were mapped. 1,895 households were systematically selected. In each household, male and female who was 12-65 years old, at least three months stayed in the sample households were listed by age separately. One person from each list was randomly selected using tables[11]. Either non-participation or only gender (male or female) in the selected household, neighborhood household will be selected systematically for replacement. As in Fig. 1, 3,790 individual were the study samples; 690 individuals were from the north, 1,272 individuals were from the northeast, 956 individuals were from the central, 534 individuals were from the south, and 338 individuals were from Bangkok metropolitan area. The survey samples size was calculated under 95% confidence interval, and design effect 11.5[9-11].

Tools
Although, the existing definition of "acquaintance" by Killworth et al was "mutually recognize each other by sight or name, can be contacted, and have had contact within the last two years, either in person, by phone or mail"[13]. To minimize recall bias, the working definition of acquaintance in this study modified a little from Killworth's definition: "mutually recognize each other by sight or name, can be contacted, and have had contact within the past year, either in person, by phone or mail". Thus, an
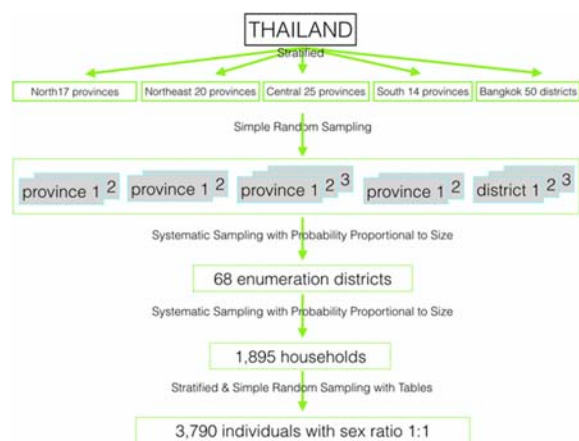

Fig. 1 Sampling method and sample size.

acquaintance was a person who met all of the following criteria: 1) a person other than oneself, including family and relatives; 2) a person one has either met directly or can recognize by name (including first name or nickname); 3) a person who can be contacted directly; 4) a person with whom one has had contact within the past year, either in person, by phone or mail (including internet communication such as e-mail); and 5) a Thai person who lives in sample household more than 3 months in the past year (the sample household must be settled more than 6 months).

Thirty individuals were invited for tool construction procedure. Each individual was asked to write 50 names of the acquaintance who were recently contacted, type of social relationship, and status/ characteristics of each name. For summation method, a sociometry procedure was used to list the types of social relationship from 1,500 names. Five experts from each geographical zone were asked to consider for indexes of item-objective congruence independently. Only the types, of which the index scores were 0.8 or above, would be selected. As a result, 19 types of social relationships such as parent, relatives, friends from school, co-workers etc. were identified.

For reference group method, 87 status/ characteristics were summarized from 1,500 names. Of these, 42 groups appeared in Thailand annual official statistics with public access. It was recommended that the prevalence between 0.1-4% of the population should be the best to be reference groups due to minimization of barrier effect as well as transmission error[14]. Only 19 groups, which were between 0.1-4% of the population in 2013 such as disable people, dead people, priest, divorce registration, etc. were selected to be reference group in this study. For standardization of the tool, 50 individual of both sex (10 from each stratum) were recruited for a four weeks test retest. Correlation between the two tests was 0.96.

Data collection

Three field teams were organized; Chiang Mai University team responsible for the upper north area, Ministry of Public Health team responsible for Bangkok area, and the rest responsible by Khon Kaen University Team. Interviewers and field supervisors were trained and tested for standard performance in data gathering process to ensure quality of data in this study. In this survey, interviewees were interviewed at home. They were asked how many members of particular subgroups they knew. They were also asked how many IDU they knew (individual perception on particular behavior).

To minimize barrier effects and transmission error in personal network size estimation, a method proposed by McCormick et al[15] was used. Respondents were asked for their first names or nicknames of their acquaintances. The survey was conducted during October-November, 2014.

Data analysis

Data double entry was employed to minimize personal mistake in data entering process. Exploratory data was done to correct the problem of outlier, extreme, and missing data. Mean Imputation was performed. Data were analyzed through descriptive statistics.

Ethics statement

The survey was conducted by research teams. At the stage of data gathering, written consent was required. Personal identifiers (names, full addresses) were stripped from the data set. The study was reviewed and approved by the Ethics Committee for Human Research at Khon Kaen University (HE571269).

Results
Characteristics of the samples

There were 3,790 participants in the study, of whom 1,895 were males and 1,895 were females. Average age for all participants was 40.0 years old with standard deviation of 15.5 (median 42.0 interquartile range 25). 90.1% were Buddhism while 8.3% were Muslims. 15.1% were currently students while 57.9% graduated with basic education and higher, in contrast with 3.0% were illiterate. 6.3% were jobless/retired, 7.8% working within family business without wages while 28.0% were employees. As in Table 1, the percentages by these characteristics were made proportionate to those of the Thai population.

Estimation of personal network size

For summation method, personal network size was calculated based on 19 subgroups. Personal network size was 249.31 (95% CI; 233.61, 265.01) with regional variation ranging from 130.38 to 335.65.

For reference group method, personal network size was calculated based on 19 reference statistics with known population size. Personal network size was 264.60 (95% CI; 207.03, 322.16) with regional variation ranging from 123.15 to 374.48. Personal network size calculations from both methods by respondents from each region are shown in Table 2.

The proportion of IDU in personal network was 0.24 persons (95% CI; 0.13, 0.35). Average number

of acquaintances to whom the IDU had come out from summation method was 75,441 persons. While an average number of acquaintances to whom the IDU had come out from reference group method was 71,083 persons. The estimated number of IDUs showed 5.8% different between the two methods of calculation.

Backward estimation
To check on the reliability of the above results, as used in the pilot study to select the subgroups with known sizes, backward estimation was done, where population size was treated as unknown and estimated it using the average network size, total population and

Table 1. Demographic characters of the study samples

Characteristics	Number	Percentage
Age		
12-24 years old	712	18.8
25-44 years old	2,645	69.8
45-65 years old	433	11.4
Religious		
Buddhist	3,419	90.1
Moslem	315	8.3
Others	59	1.6
Education		
Illiteracy	112	3.0
Elementary education	1,482	39.1
Secondary education	1,428	37.7
College and university	764	20.2
Occupation		
Private enterprise	1,537	40.6
Working with family business	295	7.8
Employee	1,060	28.0
Currently students	573	15.1
Jobless/retired	240	6.3
Others	85	2.3

the average number known. As in Fig. 2, discrepancy between known population size and population size based on backward estimation were not considerable; therefore, the study results were considered to be reliable.
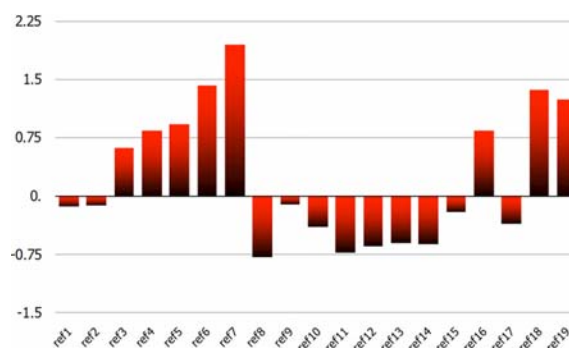
Discussion
Estimation of hard-to-reach populations by NSU method
The estimated personal network size of 264.60 in this study using reference group method was not very far from estimates from summation method, which found network sizes of 249.31. The estimated IDU prevalence of 110 for 100,000 population by reference group method was comparable to 117 by summation method. Estimated IDU in study reflect the increasing of IDU in Thailand, comparing to 2010 study with the same method. This figure corresponds to the registration database of the Office of Narcotic Control Board[16]. This outcome suggests the validity of scale-up methods for estimating the IDU population size.

Estimation of IDU population size

Fig. 2 Backward estimation on known population size.

Table 2. An average personal network size of respondents from each region by different method of calculation

	Overall respondents	Bangkok	Central	North	Northeast	South
Reference gr. mean	264.60	373.48	252.43	233.86	341.29	123.15
Reference gr. 95% CI	207.03, 322.16	277.21, 469.75	203.63, 301.23	217.76, 249.96	317.17, 365.41	108.35, 137.95
Summation mean	249.31	318.20	335.65	135.58	299.25	130.38
Summation 95% CI	233.61, 265.01	256.30, 380.09	279.54, 391.75	125.57, 145.58	275.54, 322.96	117.50, 143.25

Even though backward estimation was not considerable, it is barrier effect and transmission error still, resulting in a small difference estimated between two methods. Both methods may be applicable to other settings in need of IDU population size estimation and to estimating hard-to-reach populations other than IDU. Reference group method seems to be more preferable due to its evidence based on official statistics. In places where official statistics were not updated or unreliable, a summation method is an alternative.

Limitations of this study

The network scale-up method assumes three conditions; therefore, the accuracy of the estimate depends on the validity of these assumptions. The first assumption is that all members of the population (e.g., the total population in Thailand) have an equal chance of being acquainted with members of the group of interest with unknown size (e.g., IDU in Thailand). The second assumption is that everyone has perfect information about his or her acquaintances. The third assumption is that the respondents can accurately recall the number of acquaintances they have and provide this information in a short period of time. The biases arising from deviations from these three assumptions are called barrier effects and transmission error, respectively[17]. Additionally, surveys for hard-to-reach populations are subject to several biases. First, it could produce a response bias due to social stigmatization (sensitive data, such as drug abuse, are often under-reported). Second, there are age biases among the respondents (the younger tend to have smaller network size than the older). Third, there are selection biases because the samples are made up of volunteer[18]. However, the benefits of low cost and rapid response continue to make the use of NSU a valuable method.

The questionnaires used in the network scale-up method could have a certain degree of ambiguity. For example, the definitions of "IDU" and "personal network" are not always consistent; however, every attempt was made in this survey to minimize confusion by defining these terms for the survey respondents. Additionally, the numbers of members of groups with large populations tend to be under-reported, and the numbers of members of groups with smaller populations tend to be over-reported[19].

Preferences for reporting certain numbers may also affect the accuracy of the estimation. McCarty et al[17] have observed the tendency of respondents to report numbers in which the last digit is 0 or 5, especially when the number is more than 10, although this bias has minimal impact on the accuracy of estimation. Asking about sensitive sub-populations could lead to under-reporting of the members of such sub-populations as well, resulting in the underestimation of the corresponding network sizes. In a prior study to estimate the number of heroin users at 14 US sites, for example, Kadush has argued that the reason the estimated network size was fairly small (55) was under-reporting due to sensitivity about this particular sub-population[20].

In addition, the affiliation of the respondent with a specific sub-population has a direct impact on the estimation of the network size. For example, when a respondent has an affiliation with a certain sub-population, the respondent has a much greater chance of getting to know members of that sub-population (and vice versa)[21]. Additionally, factors such as the selection of sub-groups with known sizes and respondents with large network sizes, such as religious leaders, politicians, corporate managers, and diplomats may affect personal network size. In addition, the number of sub-groups with known sizes would affect the estimated network size. Although the sub-groups with known sizes used in this study were carefully selected, more sub-groups should be reasonably identified and used to increase the reliability of the network size estimation.

The accuracy of the assumption that IDU has similar network sizes, as other sub-populations could be a source of uncertainty regarding the estimate. In fact, Zheng et al[22] found that Americans vary greatly in their number of acquaintances; therefore, the network size of IDU could differ greatly from other sub-groups used in this study. In addition, it was suggested in the same study that Americans showed great variation in propensity to form ties to people in some groups, but little variation for other groups.

There is a procedure developed by Salganik et al[23] for adjusting for transmission error by using a game-like activity called the game of contacts in order to estimate the social visibility of groups. This method was not utilized in this study since there was an error in different name perceptions[24].

Despite these limitations, this study demonstrated the ability of network scale-up methods to estimate the size of hard-to-reach populations simply and rapidly, and serves as critically needed baseline size estimation for hard to reach populations. To improve further this method for estimating hard-to-reach populations, additional refinements in the survey design are need to take full advantage of the above

developments, adjusted to the Thailand context to address identified limitations and verification through comparison with direct methods.

Conclusion

The results of this study using network scale-up methods in estimating IDU Thailand were evidence-based. Overall, size estimation through network scale-up method appears to be an effective approach from the perspectives of rapidity, simplicity, and low cost. Using frequent and thorough size estimations of key hard-to-reach populations (such as IDU in Thailand), more effective and targeted policies should be formulated. In the field of HIV/AIDS response, such policies are required if the goals of zero new HIV infections, zero AIDS-related deaths and zero AIDS-related discrimination are required[25].

What is already known on this topic?

Regarding IDUs estimation, Asian Epidemic Model is currently used by Ministry of Public Health. However, the model used existing registration and experts' opinion to generate the figure, which is still controversial on its validity.

What this study adds?

This study introduces survey data to estimate the size of IDUs better in terms of validity and acceptability.

Acknowledgement

Potential conflicts of interest

None.

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การคาดประมาณจำนวนผู้ใช้ยาเสพติดแบบฉีดด้วยวิธีขยายเครือข่ายในประเทศไทย

มานพ คณะโต

ภูมิหลังและวัตถุประสงค์: ผู้ใช้ยาเสพติดแบบฉีดเป็นประชากรกลุ่มเข้าถึงยากกลุ่มหนึ่งที่มีความเสี่ยงสูง ต่อการแพร่ระบาดของเชื้อเอชไอวีในประเทศไทย การศึกษานี้มีวัตถุประสงค์เพื่อคาดประมาณจำนวนผู้ใช้ยาเสพติด แบบฉีดในประเทศไทยด้วยวิธีการคาดประมาณทางอ้อม

วัสดุและวิธีการ: การศึกษาที่ดำเนินการสำรวจครัวเรือนในกลุ่มตัวอย่าง 3,790 คนที่มีอายุ 12-65 ปีอาศัย อยู่ในครัวเรือนตัวอย่างไม่น้อยกว่า 3 เดือน เครือข่ายของบุคคลถูกคาดประมาณด้วยวิธีควบรวมผลและวิธีเทียบกลุ่มอ้างอิง กลุ่มตัวอย่างถูกถามถึงจำนวนของคนรู้จักและจำนวนคนที่ใช้ยาเสพติดแบบฉีด ตามการรับรู้ของตนเอง ผลจากการสำรวจด้วยวิธีขยายเครือข่ายนำไปสู่การคาดประมาณเครือข่ายของบุคคลและจำนวนคนที่ใช้ยาเสพติดแบบฉีด

ผลการศึกษา: ในการคาดประมาณผ่านเครือข่ายของบุคคล พบจำนวนคนที่ใช้ยาเสพติดแบบฉีดในประเทศไทย 71,000 คน คิดเป็นค่าคาดประมาณความชุก 110 ต่อ 100,000 ประชากร

สรุป: การคาดประมาณจำนวนผู้ใช้ยาเสพติดแบบฉีดด้วยวิธีขยายเครือข่ายเป็นวิธีการที่มีประสิทธิภาพ ประหยัดเวลา ใช้งานง่ายและมีค่าใช้จ่ายต่ำกว่าวิธีการแบบดั้งเดิม